

## CLAIMS AMENDMENT SECTION

1. (currently amended) A Land Surveyor System with Reprocessing (LSSRP) comprising:

- an AINS providing a sequence of time-indexed present position values in response to the LSSRP being moved from a first known position value at the start of a survey interval to a second known position value at the end of the survey interval,
- a Position Computing System (PCS) coupled to receive and store the sequence of time-indexed present position values as a surveyor carries the LSSRP from the first known position to the second known position,
- the PCS and the AINS being integrally coupled into a package to be carried by a surveyor, the package further comprising an input/output interface device having a means for inputting and time-indexing successive first and second known present position values at respective successive known present position fixes, each successive pair of known present position values establishing the beginning and end of a survey interval,
- the PCS having a reprocessing computer and program means [[for]] coupled to receive and store the successive time-indexed known present position fix values and for processing the indexed present position values with a smoothing algorithm to provide indexed and adjusted present position values for at least some of the indexed present position values between the first known position fix value at the start of the survey interval and the second known position fix value at the end of the survey interval,
- the PCS also having,
- a switch means for signaling the AINS and the Kalman filter that the unit is stationary by use of an algorithm, running in the PCS reprocessing computer and program means, for deducing zero velocity from computed inertial velocity.

2. (Original) The LSSRP of Claim 1 wherein the AINS uses a Kalman filter responsive to at least two sources of aiding signals,

the PCS having an aiding signal selector algorithm characterized to select the most accurate aiding signal for use by the Kalman filter from all available aiding signals.

3. (Original) The LSSRP of Claim 1 wherein the reprocessing computer and program means smoothing algorithm is a Modified Bryson-Frazier smoother (MBFS).

4. (currently amended) The LSSRP of Claim 1 wherein the reprocessing computer and program means smoothing algorithm is a modified Bryson-Frazier smoother (MBFS) mechanized using the following equations and definitions for steps and definitions:

data available to the MBFS at iteration  $k$  from the AINS-LSSRP Kalman filter:

$\Phi(k, k-1)$  transition matrix from iteration  $k-1$  to iteration  $k$ ,

$H_k$  measurement matrix ,

$K_k$  Kalman gain,

$S_k$  Kalman innovations covariance,

$\bar{\xi}_k$  innovations vector,

$\hat{\bar{x}}_k^-, \hat{\bar{x}}_k^+$  Kalman estimated error state,

$P_k^-, P_k^+$  Kalman generated estimation error VCV matrix,

and where,

the backwards extrapolation follows:

$$\bar{\lambda}_{k-1}^+ = \Phi^T(k : k-1) \bar{\lambda}_k^-, \quad (12)$$

$$\Lambda_{k-1}^+ = \Phi^T(k : k-1) \Lambda_k^- \Phi(k : k-1), \quad (13)$$

and the adjoint measurement update follows:

$$\bar{\lambda}_k^- = (I - H_k K_k) \bar{\lambda}_k^+ - H_k S_k^{-1} \bar{\xi}_k, \quad (14)$$

$$\Lambda_k^- = (I - H_k K_k)^T \Lambda_k^+ (I - H_k K_k) + H_k^T S_k H_k, \quad (15)$$

and where:

- $\bar{\lambda}_k^-$  is the a priori adjoint state vector,
- $\Lambda_k^-$  is the a priori adjoint VCV matrix,
- $\bar{\lambda}_k^+$  is the a posteriori state vector, and
- $\bar{\lambda}_k^+$  is the a posteriori adjoint VCV matrix;

and where:

the smoothed state and estimation error VCV matrix is defined by:

$$\bar{x}_k^s = \bar{x}_k^- - P_k^- \bar{\lambda}_k^- = \bar{x}_k^+ - P_k^+ \bar{\lambda}_k^+, \quad (16)$$

$$P_k^s = P_k^- (I - \Lambda_k^- P_k^-) = P_k^+ (I - \Lambda_k^+ P_k^+), \quad (17)$$

and where the smoothed state vector is defined by:

$$\bar{x}_k^s = \begin{bmatrix} \delta \bar{r}_s \\ \bar{x}_{remaining}^s \end{bmatrix} \quad (19)$$

where  $\delta \bar{r}_s$  is the smoothed estimate of AINS position error and

$\bar{x}_{remaining}^s$  is the sub-vector of smoothed error states other than  $\delta \bar{r}_s$

and where the AINS position vector  $\bar{r}_{s_k}^e$  is obtained from the error correction difference matrix (20) using earth fixed Cartesian coordinates (X,Y,Z components) as

$$\bar{r}_{s_k}^e = \bar{r}_k^e - \delta \bar{r}_s = \begin{bmatrix} \hat{r}_x^e - \delta \hat{r}_{s_x}^e \\ \hat{r}_y^e - \delta \hat{r}_{s_y}^e \\ \hat{r}_z^e - \delta \hat{r}_{s_z}^e \end{bmatrix} \quad \underline{20.}$$

[[ (20). ]]

5. (Canceled)

1 6. (currently amended) The LSSRP of Claim 1 wherein the input/output interface  
2 device having a means for inputting and time-indexing successive known present position  
3 values further comprises:  
4 a computer key pad and a read-out display electrically coupled to the PCS for  
5 inputting successive known present position values and for signaling the start of  
6 reprocessing [[.]]after inputting each successive known present position value.

7. (Original) The LSSRP of Claim 1 wherein the PCS coupled to receive and store the  
sequence of time-indexed present position values further comprises:

a mass storage memory for storing the sequence of time-indexed present position  
values.

8. (Original) The LSSRP of Claim 7 wherein the mass storage memory for storing  
the sequence of time-indexed present position values is linked to the reprocessing  
computer and program mean by a radio link.

9. (currently amended) The LSSRP of Claim 1 wherein the [[the]] switch means is a  
manually operated switch with which the surveyor manually signals the AINS [[and]]  
that the unit is stationary.

10. (currently amended) The LSSRP of Claim 1 wherein the switch means comprises a mechanical closure coupled to the package and electrically coupled to the AINS to signal the AINS that the unit is stationary, the mechanical closure being transferred by operation of a lever or plunger contacting the ground.

1 11. (Amended) A Land Surveyor System with Reprocessing (LSSRP) transported by a  
2 surveyor moving from a first known position at the start of a survey interval to a second  
3 known position at the end of the survey interval, the LSSRP comprising:

4 an Aided Inertial Navigation System (AINS) having a Kalman filter coupled to  
5 be responsive to at least a first source of aiding time-indexed values, the AINS providing  
6 a continuing sequence of time-indexed present position values,

7 a Position Computing System (PCS) having a program for storing the continuing  
8 sequence of time-indexed present position values in a memory and for outputting the  
9 time-indexed present position value of the PCS as the surveyor moves from the first  
10 known position to the second known position, the surveyor using the output time-indexed  
11 present position value to locate at least one predetermined stake position,

12 the PCS further comprising a reprocessing computer and program means activated  
13 at the second known position to access and process the stored continuing sequence of  
14 time-indexed present position values with an optimal smoothing program to provide  
15 indexed and adjusted present position values for at least some of the continuing sequence  
16 of time-indexed present position values, and wherein,

17 the PCS and the AINS are integrally coupled into a package to be carried  
18 by and used by a surveyor, the package further comprising

19 an input/output interface device having a means for inputting and time-indexing  
20 successive known present position values at respective successive known present position  
21 fixes, each successive pair of known present position values establishing the beginning  
22 and end of a survey interval, the PCS also having

23 a switch means for signaling the AINS that the package is stationary.

12. (Original) The LSSRP of Claim 11 wherein the PCS further comprises an aiding signal selector for analyzing the aiding position signals available to the AINS and for commanding the AINS to select and use the highest accuracy aiding position signal available.

13. (Original) The LSSRP of Claim 12 wherein the aiding signal selector for analyzing the aiding position signals available to the AINS monitors for loss of differential GPS and in the event differential GPS is lost, the aiding signal selector directs the AINS to not use GPS signals as aiding position signals until differential GPS is restored.

14. (Amended) The LSSRP of Claim 12 wherein the aiding signal selector is further characterized to receive all aiding position signals and to select and provide the highest accuracy aiding position signal to the AINS for use as an input to the Kalman filter.

15. (Canceled)

16. (Original) The LSSRP of Claim 11 wherein the PCS further comprises:

a mass storage memory for storing the sequence of time-indexed present position values in an array of memory locations for later recall.

17. (Original) The LSSRP of Claim 11 wherein the PCS and AINS package further comprises a switch means with which the surveyor manually signals the AINS that the unit is stationary.

18. (Canceled)

19. (Canceled)

20. (Canceled)

21. (New) The LSSRP of Claim 17 wherein the switch means is further characterized to be coupled to the package and electrically coupled to the AINS and to automatically signal the start of a ZUPD on contact with the ground.

22. (New) A Land Surveyor System with Reprocessing (LSSRP) to be carried or transported by a surveyor along a predetermined path or a zigzag pattern of parallel seismic lines to locate and record the position fixes of stakes that the surveyor positions in accordance with a pre-planned grid of predetermined locations comprising:

an AINS programmed to provide a sequence of time-indexed present position values in response to the LSSRP being moved from a first known position fix location or "tie-down" at the start of a survey interval to a second known position fix location or "tie-down" at the end of the survey interval,

a Position Computing System (PCS) coupled to the AINS to receive and store the sequence of time-indexed present position values from the AINS as the surveyor moves the Land Surveyor System with Reprocessing (LSSRP) from the first known position fix location to the second known position fix location, the PCS and the AINS being integrally coupled into

a package to be carried by a surveyor, the package further comprising:

an input/output interface device having a means for inputting successive known present position fix location values at respective successive known present position fix locations, each successive pair of known present position values establishing the beginning and the end of a survey interval,

a reprocessing computer running a reprocessing program to process the indexed present position values with a smoothing algorithm, the reprocessing computer and smoothing algorithm calculating and storing smoothed and corrected indexed and adjusted present position values at the end of each survey interval, the resulting smoothed and corrected indexed and adjusted present position values being used to correct the position value or fix location of at least one stake positioned between the first known position fix location at the start of the survey interval and the second known position fix location at the end of the survey interval, the package having

a switch means coupled to the package and electrically coupled to the PCS to signal that the package is stationary,

the PCS being coupled to receive and provide at least two sources of aiding signals to a Kalman filter, at least one source being a radio linked differentially corrected GPS signal, and



32 a signal selector or program for automatically selecting the most accurate aiding  
33 signal for use by the Kalman filter from all available aiding signal.

23.(New) The Surveyor System with Reprocessing (LSSRP) of claim 22 wherein the switch means further comprises a mechanical closure that is coupled to the package and is electrically coupled to the AINS to signal that the package is stationary, the mechanical closure being transferred by operation of a lever or plunger contacting the ground

24.(New) The Surveyor System with Reprocessing (LSSRP) of claim 22 wherein the switch means comprises an algorithm running in the AINS and or the PCS for automatically signaling when the package is stationary.